their distances from the axis of rotation, consequently we increase the strain on the combinations of the structure ; and as the strength to resist this strain varies inversely as the length, we diminish the power to resist this increased strain. By an increase in the length we also increase the effect of the resistance of the water to the rotation of the vessel in the manœuvres of tacking, wearing, and other changes of her course.

By increasing the breadth, and by breadth we mean the whole breadth of that part of the body included in the li­mits of the immersions and emersions, we increase the stability, which varies as the cube of the breadth. Also, the angular momenta of the weights, estimated from the axis of rotation, vary as the squares of their distances from that axis, and the momentum of the stroke of a wave is in­creased in the same proportion ; therefore the increase of stability is accompanied by increased violence in the mo­tions, and consequent increased strain on the combinations and materials of the structure, and especially danger to the masts, by which the safety of the vessel may be compro­mised. The stability of a ship being the quality on which the efficiency of her armament is essentially dependent, and which also, by enabling her to carry a press of sail in cir­cumstances of danger, as a lee shore, or an enemy of supe­rior force, is essential to her safety ; the only limit to its increase is involved in the consideration of easiness of mo­tion. But if this consideration be neglected, and the breadth be such that the moment of stability in proportion to the moment of sail is so large, or of such sudden increase, that the masts are endangered or the combinations of the structure prematurely destroyed, the object for which a large moment of stability was desirable is frustrated. The breadth, therefore, is limited by easiness of motion.

By increase of breadth we increase the stowage, which varies as the breadth ; but since the direct resistance to the progress of the vessel also varies as the breadth, in this case we do not gain increase of stowage without an increase of the direct resistance.

Having thus pointed out in general terms the effects of an increase either of length or breadth, we shall quote from a very able article in the fifth number of Papers on Naval Architecture, written by Mr Bennet, a member of the abo­lished School of Naval Architecture, containing some more particular observations on the breadth of vessels in proportion to their armament and in relation to their stability. “ The capacities of ships increase as the cubes of their dimensions, whereas the stability increases as the fourth power of their dimensions. The inference to be drawn from this is, that small ships should have greater relative breadth than large ships. This, however, must be understood with certain limi­tations : it may be a general, but not an universal truth. Were all ships homogeneous ; thus, if a navy consisted en­tirely of corvettes, the corvette of eighteen guns ought to be relatively broader than the corvette of 120 guns : this is a rule without any exception. It may be farther observ­ed from the previous remarks, that the corvette of eighteen guns should be relatively broader than the three-decked ship of 120 guns ; but if a ship were built to carry 120 guns on four or even on five decks, her relative breadth should then approximate to, and should most likely exceed, that of the corvette, in order to insure sufficient stability. The consideration of this simple case may tend to elucidate the principles of stability when applied to cases of greater diffi­culty. If a three-decked ship of 120 guns is to carry the same force on a greater number of decks, her absolute length would of course be reduced ; and supposing her breadth to remain the same, the positive part of the expres­sion of stability would be thereby diminished. The dis­placement, which is one element of the negative part of the expression, would probably remain nearly the same, as the additional weight of topside might counterbalance the

reduction of weight Occasioned by less length. If the dis­placement be equal in each case, the draught of water would be increased from the diminution of length ; this would lower the centre of gravity of displacement, which, together with the centre of gravity of the ship being raised by the additional weight above the water, would increase the distance between the centre of gravity of the ship and that of the displacement. On the whole, therefore, the po­sitive part of the expression would be diminished and the negative part increased, so that the stability would be less in a ship of the same force and breadth as another ship, but which carried her guns on a greater number of decks.

“ Having seen the necessity, in the case of a ship carrying the same number and weight of guns as another ship, but on more decks, of increasing the breadth, in order to avoid a deficiency of stability, we may evidently trace the same principle existing between the largest ship of an inferior class, and the least ship of a superior class, in which, if the number of guns be not equal, it approximates sufficiently to make the application apparent ; so that in the several gra­dations of corvettes, frigates, two-decked ships, and three- decked ships, the least vessel of each class is liable to be wanting in stability, from its small comparative dimensions not sufficiently counteracting the effect of additional decks and guns. In this case, therefore, above all others, particu­lar care should be taken to give sufficient breadth to com­pensate for a tendency to deficiency in stability ; so that, without much liability to error, we may conclude,—

“ 1st, That the small frigate should be relatively broader than the large corvette.

“ 2d, That the small two-decker should be relatively broader than the large frigate.

“ 3d, That the small three-decker should be relatively broader than the large two-decker.

“ Between each of these varieties there will be a certain point, if the expression may be used, where the superior and inferior classes of ships should have the same ratio of length to breadth. This arises from the enlargement of their dimensions increasing the stability in a greater proportion than the weight of additional decks and guns diminishes the stability. Thus,

“ 4th, The middling-sized frigate should have the same ratio of length to breadth as the large corvette.

“ 5th, The middling-sized two-decker should have the same ratio of length to breadth as the large frigate.

“ 6th, The middling-sized three-decker should have the same ratio of length to breadth as the large two-decker.

“ As corollaries from the first three observations, we may remark,

“ 7th, That the large corvette should be relatively broader than the large frigate.

“ 8th, That the large frigate should be relatively broader than the large two-decker.

“ 9th, That the large two-decker should be relatively broader than the large three-decker.”

The depth or draught of water is more dependent on local circumstances than on accurate principles. A fleet intended to traverse the Atlantic may have far different draughts of water from the ships of one that is destined for the Baltic. Cruizers for the open seas may be much deeper than those intended to watch an enemy’s coast.

The average light draught of water which a ship will swim at, or the average load draught of water that will be found necessary for her, may be easily and accurately ap­proximated to by means of the calculations of the displace­ment which have been already explained.

The actual water-line, with the difference of draught of water which it may be considered necessary to insure to the vessel, may also be approximated to in the design of a ship, or approximately determined from the drawing of a ship already designed, on the following principle. Suppose